

What is claimed is:

1. A high strength and high toughness magnesium alloy containing "a" atomic% of Zn, "b" atomic% of Y and a residue of Mg, wherein "a" and "b" satisfy the following expressions (1) to (3):

(1)  $0.5 \leq a < 5.0$ ;

(2)  $0.5 < b < 5.0$ ; and

(3)  $2/3a - 5/6 \leq b$ .

2. A high strength and high toughness magnesium alloy according to claim 1 comprising a plastically worked product which has a hcp structured magnesium phase and is produced by subjecting a magnesium alloy casting product to a plastic working.

15

3. A high strength and high toughness magnesium alloy comprising a plastically worked product which is produced by preparing a magnesium alloy casting product comprising "a" atomic% of Zn, "b" atomic% of Y and a residue of Mg, wherein "a" and "b" satisfy the following expressions (1) to (3), and then subjecting said magnesium alloy casting product to a plastic working, wherein said plastically worked product has a hcp structured magnesium phase and a long period stacking ordered structure phase at room temperature:

25

(1)  $0.5 \leq a < 5.0$ ;

(2)  $0.5 < b < 5.0$ ; and

(3)  $2/3a - 5/6 \leq b$ .

4. A high strength and high toughness magnesium alloy comprising a plastically worked product which is produced by preparing a magnesium alloy casting product comprising "a" atomic% of Zn, "b" atomic% of Y and a residue of Mg, wherein "a" and "b" satisfy the following expressions (1) to (3), and then subjecting said magnesium alloy casting product to a plastic working and a heat treatment, wherein said plastically worked product has a hcp structured magnesium phase and a long period stacking ordered structure phase at room temperature:

(1)  $0.5 \leq a < 5.0$ ;

(2)  $0.5 < b < 5.0$ ; and

(3)  $2/3a - 5/6 \leq b$ .

5. A high strength and high toughness magnesium alloy according to any one of claims 2 to 4, wherein said hcp structured magnesium phase has an average particle size of  $2\mu\text{m}$  or more.

① 6. A high strength and high toughness magnesium alloy according to any one of claims 2 to 5, wherein said long period stacking ordered structure phase has at least single-digit smaller dislocation density than said hcp structured magnesium phase.

① 7. A high strength and high toughness magnesium alloy according to any one of claims 3 to 6, wherein said long period stacking ordered structure phase has a crystal grain having a volume fraction of 5% or more.

① 8. A high strength and high toughness magnesium alloy according to any one of claims 2 to 7, wherein the plastically worked product contains at least one kind of precipitation selected from the group consisting of a compound of Mg and rare-earth element, a compound of Mg and Zn, a compound of Zn and rare-earth element and a compound of Mg, Zn and rare-earth element.

① 9. A high strength and high toughness magnesium alloy according to claim 8, wherein the at least one kind of precipitation has a total volume fraction of higher than 0 to 40% or less.

① 10. A high strength and high toughness magnesium alloy according to any one of claims 2 to 9, wherein said plastic working is carried out by at least one process in a rolling, an extrusion, an ECAE working, a drawing, a forging, a press, a form rolling, a bending, a FSW working and a cyclic working of theses workings.

① 11. A high strength and high toughness magnesium alloy

according to any one of claims 2 to 10, wherein a total strain amount when said plastic working is carried out is 15 and below.

① 5 12. A high strength and high toughness magnesium alloy according to any one of claims 2 to 10, wherein a total strain amount when the plastic working is carried out is 10 and below.

① 10 13. A high strength and high toughness magnesium alloy according to any one of claims 1 to 12, wherein Mg contains "c" atomic%, in a total amount, of at least one element selected from the group consisting of Yb, Tb, Sm and Nd, wherein "c" satisfies the following expressions

15 (4) and (5),  
(4)  $0 \leq c \leq 3.0$  and  
(5)  $0.2 \leq b+c \leq 6.0$ .

① 20 14. A high strength and high toughness magnesium alloy according to any one of claims 1 to 12, wherein Mg contains "c" atomic%, in a total amount, of at least one element selected from the group consisting of La, Ce, Pr, Eu, Mm and Gd, wherein "c" satisfies the following expressions (4) and (5) or (5) and (6):

25 (4)  $0 \leq c < 2.0$ ;  
(5)  $0.2 \leq b+c \leq 6.0$ ; and  
(6)  $c/b \leq 1.5$ .

① 15. A high strength and high toughness magnesium alloy according to any one of claims 1 to 12, wherein Mg contains "c" atomic%, in a total amount, of at least one  
5 element selected from the group consisting of Yb, Tb, Sm and Nd and "d" atomic%, in a total amount, of at least one element selected from the group consisting of La, Ce, Pr, Eu, Mm and Gd, wherein "c" and "d" satisfy the following expressions (4) to (6) or (6) and (7):

10 (4)  $0 \leq c \leq 3.0$ ;

(5)  $0 \leq d < 2.0$ ;

(6)  $0.2 \leq b + c + d \leq 6.0$ ; and

(7)  $d/b \leq 1.5$ .

15 16. A high strength and high toughness magnesium alloy comprising "a" atomic% of Zn, "b" atomic% of Y and a residue of Mg, wherein "a" and "b" satisfy the following expressions (1) to (3):

(1)  $0.25 \leq a \leq 5.0$ ;

20 (2)  $0.5 \leq b \leq 0.5$ ; and

(3)  $0.5a \leq b$ .

17. A high strength and high toughness magnesium alloy according to claim 16 comprising a plastically worked  
25 product which has a hcp structured magnesium phase and is produced by cutting a magnesium alloy casting product and then subjecting said magnesium alloy casting product

to a plastic working.

18. A high strength and high toughness magnesium alloy comprising a plastically worked product which is produced by preparing a magnesium alloy casting product comprising "a" atomic% of Zn, "b" atomic% of Y and a residue of Mg, wherein "a" and "b" satisfy the following expressions (1) to (3), then cutting said magnesium alloy casting product to form a chip-shaped casting product and then solidifying said ship-shaped casting product by a plastic working, wherein said plastically worked product has a hcp structured magnesium phase and a long period stacking ordered structure phase at room temperature:

- 15 (1)  $0.25 \leq a \leq 5.0$ ;  
(2)  $0.5 \leq b \leq 5.0$ ; and  
(3)  $0.5a \leq b$ .

19. A high strength and high toughness magnesium alloy comprising a plastically worked product which is produced by preparing a magnesium alloy casting product comprising "a" atomic% of Zn, "b" atomic% of Y and a residue of Mg, wherein "a" and "b" satisfy the following expressions (1) to (3), then cutting said magnesium alloy casting product to form a chip-shaped casting product, solidifying said chip-shaped casting product by a plastic working to form said plastically worked

product and then subjecting said plastically worked product to a heat treatment, wherein said plastically worked product after subjecting to said heat treatment has a hcp structured magnesium phase and a long period stacking ordered structure phase at room temperature:

- (1)  $0.25 \leq a \leq 5.0$ ;
- (2)  $0.5 \leq b \leq 5.0$ ; and
- (3)  $0.5a \leq b$ .

20. A high strength and high toughness magnesium alloy according to any one of claims 17 to 19, wherein said hcp structured magnesium phase has an average particle size of  $0.1\mu\text{m}$  or more.

① 21. A high strength and high toughness magnesium alloy according to any one of claims 17 to 20, wherein said long period stacking ordered structure phase preferably has at least single-digit smaller dislocation density than said hcp structured magnesium phase.

20

① 22. A high strength and high toughness magnesium alloy according to any one of claims 18 to 21, wherein said long period stacking ordered structure phase has a crystal grain having a volume fraction of 5% or more.

25

① 23. A high strength and high toughness magnesium alloy according to any one of claims 17 to 22, wherein said

plastically worked product contains at least one kind of precipitation selected from the group consisting of a compound of Mg and rare-earth element, a compound of Mg and Zn, a compound of Zn and rare-earth element and a  
5 compound of Mg, Zn and rare-earth element.

① 24. A high strength and high toughness magnesium alloy according to claim 23, wherein said at least one kind of precipitation has a total volume fraction of higher than  
10 0 to 40% or less.

① 25. A high strength and high toughness magnesium alloy according to any one of claims 17 to 24, wherein said plastic working is carried out by at least one process  
15 in a rolling, an extrusion, a ECAE working, a drawing, a forging, a press, a form rolling, a bending, a FSW working and a cyclic working of theses workings.

① 26. A high strength and high toughness magnesium alloy  
20 according to any one of claims 17 to 25, wherein a total strain amount when said plastic working is carried out is 15 and below.

① 27. A high strength and high toughness magnesium alloy  
25 according to any one of claims 17 to 25, wherein a total strain amount when said plastic working is carried out is 10 and below.



① 28. A high strength and high toughness magnesium alloy according to any one of claims 16 to 27, wherein Mg contains "c" atomic%, in a total amount, of at least one  
5 element selected from the group consisting of Yb, Tb, Sm and Nd, wherein "c" satisfies the following expressions (4) and (5):

(4)  $0 \leq c \leq 3.0$ ; and

(5)  $0.1 \leq b+c \leq 6.0$ .

10

① 29. A high strength and high toughness magnesium alloy according to any one of claims 16 to 27, wherein Mg contains "c" atomic%, in a total amount, of at least one  
15 element selected from the group consisting of La, Ce, Pr, Eu, Mm and Gd, wherein "c" satisfies the following expressions (4) and (5):

(4)  $0 \leq c \leq 3.0$ ; and

(5)  $0.1 \leq b+c \leq 6.0$ .

① 30. A high strength and high toughness magnesium alloy according to any one of claims 16 to 27, wherein Mg contains "c" atomic%, in a total amount, of at least one  
25 element selected from the group consisting of Yb, Tb, Sm and Nd and "d" atomic%, in a total amount, of at least one element selected from the group consisting of La, Ce, Pr, Eu, Mm and Gd, wherein "c" and "d" satisfy the following expressions (4) to (6):

(4)  $0 \leq c \leq 3.0$ ;

(5)  $0 \leq d \leq 3.0$ ; and

(6)  $0.1 \leq b+c+d \leq 6.0$ .

① 5 31. A high strength and high toughness magnesium alloy according to any one of claims 1 to 30, wherein Mg contains larger than 0 to 2.5 atomic% or less, in a total amount, of at least one element selected from the group consisting of Al, Th, Ca, Si, Mn, Zr, Ti, Hf, Nb,  
10 Ag, Sr, Sc, B, C, Sn, Au, Ba, Ge, Bi, Ga, In, Ir, Li, Pd, Sb and V.

32. A method of producing a high strength and high toughness magnesium alloy comprising:

15 a step for preparing a magnesium alloy casting product comprising "a" atomic% of Zn, "b" atomic% of Y and a residue of Mg, wherein "a" and "b" satisfy the following expressions (1) to (3), and

a step for producing a plastically worked product  
20 by subjecting said magnesium alloy casting product to a plastic working:

(1)  $0.5 \leq a < 5.0$ ;

(2)  $0.5 < b < 5.0$ ; and

(3)  $2/3a - 5/6 \leq b$ .

25

33. A method of producing a high strength and high toughness magnesium alloy according to claim 32, wherein

said magnesium alloy casting product has a hcp structured magnesium phase and a long period stacking ordered structure phase.

5 34. A method of producing a high strength and high toughness magnesium alloy according to claim 32 or claim 33, wherein Mg contains "c" atomic%, in a total amount, of at least one element selected from the group consisting of Yb, Tb, Sm and Nd, wherein "c" satisfies  
10 the following expressions (4) and (5):

(4)  $0 \leq c \leq 3.0$ ; and

(5)  $0.2 \leq b+c \leq 6.0$ .

35. A method of producing a high strength and high  
15 toughness magnesium alloy according to claim 32 or claim 33, wherein Mg contains "c" atomic%, in a total amount, of at least one element selected from the group consisting of La, Ce, Pr, Eu, Mm and Gd, wherein "c" satisfies the following expressions (4) and (5) or (5)  
20 and (6):

(4)  $0 \leq c < 2.0$ ;

(5)  $0.2 \leq b+c \leq 6.0$ ; and

(6)  $c/b \leq 1.5$ .

25 36. A method of producing a high strength and high toughness magnesium alloy according to claim 32 or claim 33, wherein Mg contains "c" atomic%, in a total amount,

of at least one element selected from the group consisting of Yb, Tb, Sm and Nd and "d" atomic%, in a total amount, of at least one element selected from the group consisting of La, Ce, Pr, Eu, Mm and Gd, wherein  
5 "c" and "d" satisfy the following expressions (4) to (6) or (6) and (7):

(4)  $0 \leq c \leq 3.0$ ;

(5)  $0 \leq d < 2.0$ ;

(6)  $0.2 \leq b+c+d \leq 6.0$ ; and

10 (7)  $d/b \leq 1.5$ .

37. A method of producing a high strength and high toughness magnesium alloy comprising:

a step for preparing a magnesium alloy casting  
15 product containing "a" atomic% of Zn, "b" atomic% of Y and a residue of Mg, wherein "a" and "b" satisfy the following expressions (1) to (3);

a step for producing a chip-shaped casting product by cutting said magnesium alloy casting product; and

20 a step for producing a plastically worked product by subjecting said chip-shaped casting product to a plastic working:

(1)  $0.25 \leq a \leq 5.0$ ;

(2)  $0.5 \leq b \leq 5.0$ ; and

25 (3)  $0.5a \leq b$ .

38. A method of producing a high strength and high

toughness magnesium alloy according to claim 37, wherein said magnesium alloy casting product has a hcp structured magnesium phase and a long period stacking ordered structure phase.

5

39. A method of producing a high strength and high toughness magnesium alloy according to claim 37 or claim 38, wherein Mg contains "c" atomic%, in a total amount, of at least one element selected from the group consisting of Yb, Tb, Sm and Nd, wherein "c" satisfies the following expressions (4) and (5):

(4)  $0 \leq c \leq 3.0$ ; and

(5)  $0.1 \leq b+c \leq 6.0$ .

15 40. A method of producing a high strength and high toughness magnesium alloy according to claim 37 or claim 38, wherein Mg contains "c" atomic%, in a total amount, of at least one element selected from the group consisting of La, Ce, Pr, Eu, Mm and Gd, wherein "c" satisfies the following expressions (4) and (5):

(4)  $0 \leq c \leq 3.0$ ; and

(5)  $0.1 \leq b+c \leq 6.0$ .

25 41. A method of producing a high strength and high toughness magnesium alloy according to claim 37 or claim 38, wherein Mg contains "c" atomic%, in a total amount, of at least one element selected from the group

consisting of Yb, Tb, Sm and Nd and "d" atomic%, in a total amount, of at least one element selected from the group consisting of La, Ce, Pr, Eu, Mm and Gd, wherein "c" and "d" satisfy the following expressions (4) to (6):

(4)  $0 \leq c \leq 3.0$ ;

(5)  $0 \leq d \leq 3.0$ ; and

(6)  $0.1 \leq b+c+d \leq 6.0$ .

① 42. A method of producing a high strength and high toughness magnesium alloy according to any one of claims 32 to 41, wherein Mg contains larger than 0 atomic% to 2.5 atomic% or less, in a total amount, of at least one element selected from the group consisting of Al, Th, Ca, Si, Mn, Zr, Ti, Hf, Nb, Ag, Sr, Sc, B, C, Sn, Au, Ba, Ge, Bi, Ga, In, Ir, Li, Pd, Sb and V.

① 43. A method of producing a the high strength and high toughness magnesium alloy according to any one of claims 32 to 42, wherein said plastic working is carried out by at least one process in a rolling, a extrusion, a ECAE working, a drawing, a forging, a press, a form rolling, a bending, a FSW working and a cyclic working of theses workings.

25

① 44. A method of producing a high strength and high toughness magnesium alloy according to any one of claims

32 to 43, wherein a total strain amount when said plastic working is carried out is 15 and below.

① 45. A method of producing a high strength and high  
5 toughness magnesium alloy according to any one of claims  
32 to 43, wherein a total strain amount when said  
plastic working is carried out is 10 and below.

① 46. A method of producing a high strength and high  
10 toughness magnesium alloy according to any one of claims  
32 to 45 further comprising a step for heat-treating  
said plastically worked product after said step for  
producing said plastically worked product.

① 15 47. A method of producing a high strength and high  
toughness magnesium alloy according to claim 46, wherein  
said heat treatment is carried out under a condition of  
a temperature of 200°C to lower than 500°C and a treating  
period of 10 minutes to shorter than 24 hours.

20 ① 48. A method of producing a high strength and high  
toughness magnesium alloy according to any one of claims  
32 to 47, wherein said magnesium alloy after subjecting  
to said plastic working has a hcp structured phase  
25 preferably having at least single-digit larger  
dislocation density than a long period stacking ordered  
structure magnesium phase.